Measurement of radon gas concentration in fertilizer samples by using nuclear track detector (CR-39)

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Abstract

In the present work, we have measured the radon gas concentration in ten fertilizers samples for three kinds {mixed fertilizer (M.F), triple super phosphate (T.S.P), single super phosphate (S.S.P)} by using alpha-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector.

The results obtained have shown that the highest average radon gas concentration in fertilizer samples was found in triple super phosphate sample (T.S.P), which was (177.5 Bq/m^3) (Iran origin), while the lowest average radon gas concentration was found in single super phosphate (S.S.P) sample, which was (72.2 Bq/m^3) (Iraq origin) .The present results show that the radon gas concentration in all fertilizers samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency.

قياس تركيز غاز الرادون في نماذج السماد باستخدام كاشف الأثر النووي (CR-39)

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الخلاصة

في هذا البحث تم قياس تركيز غاز الرادون في عشر نماذج سماد ولثلاثةأنواع (السماد المركب,سوبر فوسفات الثلاثي , سوبر فوسفات الأحادي)باستخدام تقنية عد آثار جسيمات الفا المنبعثة من غاز الرادون في كاشف الأثر النووي (CR-39).

وقد أوضحت النتائج التي حصلنا عليها أن أعلى معدل لتراكيز غازالرادون في نماذج السماد كانت في نموذج سوبر فوسفات الثلاثي (177.5 Bq/m^3) (إيراني المنشأ) بينما كان اقل معدل لتراكيز غاز الرادون في نماذج السماد كانت في نموذج سوبر فوسفات الأحادي (72.2 Bq/m^3) (عراقي المنشأ).

النتائج الحاليةتبين ان تراكيز غاز الرادون في جميع نماذج السماد كانت ضمن الحدود المسموحة للوكالة الدولية للوقاية من الإشعاع.

Introduction

The raw material used in production of some fertilizers is phosphate ore containing various amounts of natural radioactive elements. During phosphate ore processing, owing to chemical properties of Radium, practically all (^{226}Ra) gets incorporated into phosphogypsum and remains in disequilibrium status when compared to radioactivity levels contained in the raw material. Most of the phosphogypsum is considered waste and is stockpiled or discharged into the aquatic environment [1].Potential issues of concern resulting from phospho-gypsum disposal are its environmental impacts; possible increases in radio- nuclides in soils or in groundwater and consequential ingestion by humans through exposure routes such as drinking water and food chain [2]. Once ,deposited in bone tissue ,(^{226}Ra) has a high potential for causing biological damage through continuous irradiation of human skeleton over many years and may induce bone sarcoma [3].

The natural radionuclides of concern are mainly Potassium, Uranium Thorium, and the radio-nuclides that are created as their radioactive decay chains. Emanation of Radon gas (e.g. ,^{222}Rn and ^{220} Rn of lifetimes 3.8 d and 55.6s, respectively) into air occurs as a product of uranium (^{238} U) and thorium (^{232}Th) decay chains, respectively. The short lived decay products of radon are responsible for most of the hazards by inhalation. The hazard of Radon comes from its radioactive progeny, which use their physical properties to spread or attach like aerosols do, trapped in the lung and depositing their alpha-particle energies in the tissue, producing higher ionization density than beta particles or gamma-rays. Lung cancer, skin cancer, and kidney diseases are the health effects attributed to inhalation of radon-decay products [4]. The sources of radon gas are the building materials and its components, ground water, and soil [5]. The radiological impact from the above nuclides is due to radiation exposure of the body by the gamma rays and irradiation of the lung tissues from inhalation of Radon and its progeny [6]. From the natural risk point of view, it is necessary to know the dose limits of public exposures and to measure the natural environmental radiation level provided by ground, air, water, foods, building interiors, etc., for the estimation of the exposures to natural radiation sources. [7].

Experimental Part

The determination of the concentrations of alpha particles emitted from radon gas in fertilizer samples were performed by using the nuclear track detector (CR-39) of thickness (250 μm) and area of about (1×1 cm^2).

The radon gas concentration in fertilizer samples was obtained by using the sealed-cup technique as shown in Fig. (1).

After the irradiation time (45 day), the (CR-39) track detectors were etched in (6.25 N), (NaOH) at temperature of (60 C^o) for (6 h), and the tracks density were recorded using an optical microscope with magnification (400x).The density of the tracks (ρ) in the samples were calculated according to the following relation [8].

$$\text{Track density } (\rho) = \frac{\text{Average number of total pits (tracks)}}{\text{Area of field view}} \quad ......(1)$$

The radon gas concentration in the fertilizer samples were obtained by the comparison between track densities registered on the detectors of the sample and that of the standard fertilizer samples which are shown in Fig.(2), using the relation [9]:

$$C_x = \rho_x \,.\, (C_s / \rho_s) \quad .... (2)$$

Where :

C_x : alpha particles concentration in the unknown sample.

C_s : alpha particles concentration in the standard sample.

ρ_x : track density of the unknown sample (track/mm^2).

ρ_s : track density of the standard sample (track/mm^2).

Results and Discussion

Our present investigation is based on the study of 10 samples from different kinds of fertilizer which was available in the local market, some of them were Iraqi made and the others from different countries like, (Iraq, Italy, Iran, Lebanon and Jordan) and in three kinds {mixed fertilizer (M.F),triple super phosphate (T.S.P),single super phosphate (S.S.P)} ,then found the radon gas concentrations by using alpha-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector.

Table (1) present radon gas concentration for fertilizer samples in different countries, we can show that ,the highest average radon gas concentration in fertilizer samples was found in triple super phosphate (T.S.P), (origin Iran) which was (177.5 Bq/m^3), while the lowest average radon gas concentration in fertilizer samples was found in single super phosphate (S.S.P), (origin Iraq) which was (72.2 Bq/m^3) .

The present results show that the radon gas concentration in all fertilizers samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency which is (200 Bq/m^3) in soil sample [10].

It might be mentioned that ,thoron gas is an alpha emitter which is also present in fertilizer environments, however ,the average diffusion distance of thoron gas is very small compared to that of radon, which means that the present results might also contained a small amount of thoron , and therefore might be considered roughly as an upper limit results which are still within the allowed limit of (ICRP) agency . Also it should be remembered that the half –lives of radon and thoron are (3.82 d) and (56 s) respectively. However ,the present result might be more refined be using , for example ,a filter to separate radon gas from thoron gas [11].

Table (1) show the radon gas concentration for fertilizer samples from different countries

No. of sample	Origin	Kind of fertilizer		Samples				
				1	2	3	4	Mean
1	Iran	M.F	**Radon Concentration (Bq/m^3)**	193.1	186.2	151.7	1144.8	168.9
			Track density ($Track .mm^{-2}$)	28	27	22	21	24.5
2	Jordan	M.F	**Radon Concentration (Bq/m^3)**	179.3	138	138	117.2	143.1
			Track density ($Track .mm^{-2}$)	26	20	20	17	20.75
3	Iraq	M.F	**Radon Concentration (Bq/m^3)**	165.5	151.7	110.3	96.6	131
			Track density ($Track .mm^{-2}$)	24	22	16	14	19
4	Italy	M.F	**Radon Concentration (Bq/m^3)**	165.5	138	110.3	75.8	122.4
			Track density ($Track .mm^{-2}$)	24	20	16	11	17.75
5	Jordan	T.S.P	**Radon Concentration (Bq/m^3)**	200	172.4	151.7	138	165.5
			Track density ($Track .mm^{-2}$)	29	25	22	20	24
6	Iran	T.S.P	**Radon Concentration (Bq/m^3)**	213.8	200	165.5	131	177.5
			Track density ($Track .mm^{-2}$)	31	29	24	19	25.7
7	Iran	S.S.P	**Radon Concentration (Bq/m^3)**	165.5	138	75.8	48.2	106.8
			Track density ($Track .mm^{-2}$)	24	20	11	7	15.5
8	Lebanon	S.S.P	**Radon Concentration (Bq/m^3)**	138	117.2	89.6	62	101.7
			Track density	20	17	13	9	14.7

			(Track .mm^{-2})					
9	Jordan	S.S.P	**Radon Concentration (Bq/m^3)**	**131**	**110.3**	**75.8**	**41.3**	**89.6**
			Track density (Track .mm^{-2})	**19**	**16**	**11**	**6**	**13**
10	Iraq	S.S.P	**Radon Concentration (Bq/m^3)**	**96**	**82.7**	**62**	**48.2**	**72.2**
			Track density (Track .mm^{-2})	**14**	**12**	**9**	**7**	**10.5**

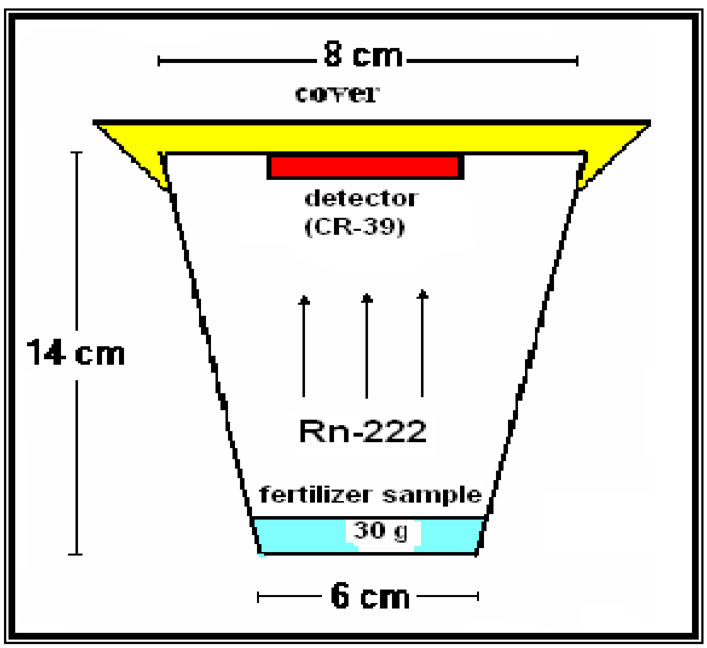

Fig. (1) A schematic diagram of the sealed-cup technique in fertilizer sample.

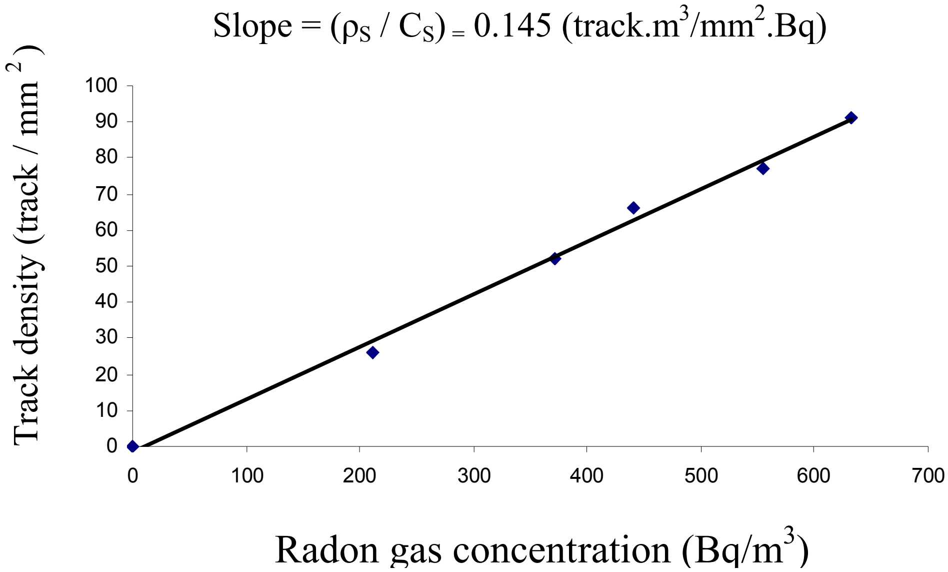

Fig. (2) relation of radon gas concentration and track density in standard samples[12].

Conclusions

From the present work, it can be concluded that the highest average radon gas concentration in fertilizer samples was found in triple super phosphate sample (T.S.P), which was (177.5 Bq/m^3) (Iran origin), while the lowest average radon gas concentration in fertilizer samples was found in single super phosphate (S.S.P) sample, which was (72.2 Bq/m^3) (Iraq origin) . The present results show that the radon gas concentration in all fertilizer samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency.

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